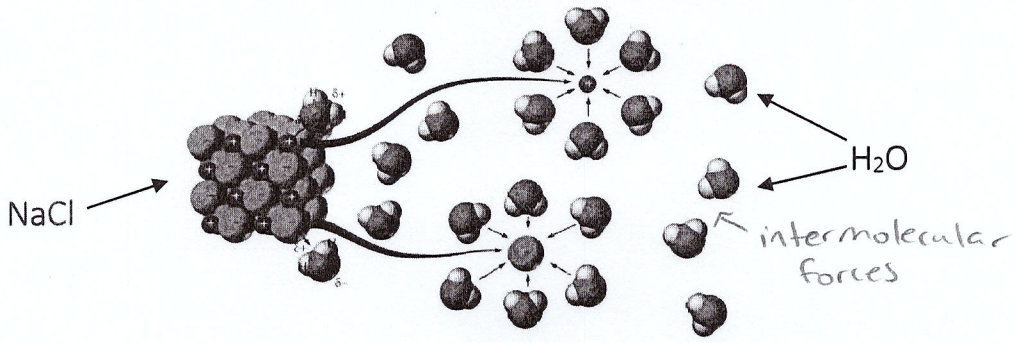
The Process of Dissolving

- Recall that solutions are made by dissolving one substance in another
- Dissolving is a *physical change*; not a chemical change.
  - A **physical change** involves breaking and forming *intermolecular* bonds. For example, dissolving sugar in water just disperses the sugar molecules into the water, but the individual sugar molecules still remain unchanged
  - A **chemical change** involves breaking and forming *intramolecular* bonds. For example, iron metal, $Fe_{(s)}$ reacts with water, $H_2O_{(l)}$, to form rust, $Fe_2O_{3(s)}$

- When dissolving occurs, the intermolecular bonds between the solute particles break apart. Some of the intermolecular bonds between solvent particles must also break.
  - The individual solute particles are now attracted to the solvent particles; reforming new intermolecular bonds between the solute and the solvent



Breaking

① H_2O - H_2O intermolecular bonds

② N-Cl bonds

Forming

① H_2O - Na^+

② H_2O - Cl^-

} intermolecular bonds

- Every time a solute dissolves, bonds are both broken and formed
  - In order to break bonds, energy is required
  - Whenever bonds are formed, energy is released
- If more energy is released from bonds forming than the energy required for bond breaking, the dissolving process will be *exothermic*
  - A reaction is **exothermic** if the overall energy is being released/lost
  - Exothermic reactions cause the surroundings to increase in temperature because energy is being released/lost to the surroundings

$E_{\text{bond breaking}} < E_{\text{bond forming}}$

$E_{\text{absorbed}} < E_{\text{released}}$

- If more energy is required for bond breaking than the energy released from bond making, the dissolving process will be *endothermic*
  - A reaction is **endothermic** if the overall energy is being absorbed/gained
  - Endothermic reactions cause the surroundings to decrease in temperature because energy is being absorbed/gained from the surroundings

$$E_{\text{bond breaking}} > E_{\text{bond forming}}$$

$$E_{\text{required}} > E_{\text{released}}$$

- **Dissociation** reactions show how a soluble ionic compound breaks apart into its ions when dissolved in water
  - ions: have a charge
  - soluble: check solubility table in data booklet!

EXAMPLES: Write the dissociation equation that shows what happens to each chemical when mixed with water.

1. Potassium chloride, KCl

$$KCl_{(aq)} \longrightarrow K^+_{(aq)} + Cl^-_{(aq)}$$

2. Barium hydroxide, $Ba(OH)_2$

↳ not soluble!

3. Aluminum sulphate, $Al_2(SO_4)_3$

$$Al_2(SO_4)_{3(aq)} \longrightarrow 2Al^{3+}_{(aq)} + 3SO_4^{2-}{}_{(aq)}$$

4. Iron (II) fluoride, FeF_2

$$FeF_{2(aq)} \longrightarrow Fe^{2+}_{(aq)} + 2F^-_{(aq)}$$

- Notice with dissociation reactions, it is not necessary to write water, $H_2O_{(l)}$, as a reactant or a product even though water is present
  - Water is not included because it is not consumed or altered during the reaction
  - The subscript (aq) indicates to the reader that the reaction is taking place in water

*****Now try Practice Problems*****

Practice Problems

1. Describe the process that takes place when a teaspoon of sugar dissolves in a cup of coffee in terms of bonds breaking and bond making.

2. When crystalline urea is dissolved in water, the solution becomes very cold. Explain what happens when urea dissolves in water that causes it to become cold.

3. Write the dissociation reactions for the following compounds.

   a. $NaCl_{(s)}$

   b. $KOH_{(s)}$

   c. $Na_2SO_{4(aq)}$

   d. $CaF_{2(s)}$

   e. $(NH_4)_3PO_{4(aq)}$

   f. $Fe_2(SO_4)_{3(aq)}$

Answers:

1. The intermolecular bonds between the individual sugar molecules break and some of the intermolecular bonds between the water molecules break as well. This process of breaking bonds requires/absorbs energy from the surroundings. The water molecules are then attracted to the individual sugar molecules and form new bonds with the individual sugar molecules. Reforming bonds will release energy to the surroundings. The sugar dissolves in the water/coffee because the individual sugar particles are pulled apart from one another and dispersed throughout the coffee/water.

2. The dissolving of urea must be an endothermic reaction if the surroundings become cold. This means that the overall energy required for bond breaking is greater than the energy released from bond making.

3.

a. $NaCl_{(aq)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

b. $KOH_{(aq)} \longrightarrow K^+ + OH^-_{(aq)}$

c. $Na_2SO_{4(aq)} \longrightarrow 2Na^+_{(aq)} + SO_4{}^{2-}_{(aq)}$

d. insoluble in water

e. $(NH_4)_3PO_{4(aq)} \longrightarrow 3NH_4{}^+_{(aq)} + PO_4{}^{3-}_{(aq)}$

f. $Fe_2(SO_4)_{3(aq)} \longrightarrow 2Fe^{3+}_{(aq)} + 3SO_4{}^{2-}_{(aq)}$